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**ANALYSIS OF HUMANITARIAN ASSISTANCE
CARGO TRANSPORTATION**

by

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June 2012

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ANALYSIS OF HUMANITARIAN ASSISTANCE CARGO TRANSPORTATION

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ABSTRACT

Humanitarian assistance is of growing importance to the United States and the Department of Defense's strategic objectives. Thus, United States combatant commands increasingly rely on humanitarian assistance cargo transportation programs to deliver material to people in need in their areas of responsibility. This report analyzes the options available to these commands in seeking humanitarian assistance cargo transportation. The report offers a description of current operations, with a specific focus on the European area of responsibility, where these programs have had limited activity.

The analysis reaches the following conclusions: (1) currently no transportation program exists that focuses on providing a quality of service to combatant commands' humanitarian assistance transportation needs; (2) legal, fiscal, and operational mechanisms exist and are outlined to create such a program; and (3) exclusively space-available transportation is generally insufficient for providing the quality of service that may be required for relationship-building through humanitarian assistance cargo transportation, and contract shipping may be necessary. These conclusions are placed in the context of current humanitarian assistance operations, and relevant operational considerations are highlighted throughout the report. The analysis is based on both a quantitative model of transportation, as well as detailed conversations with humanitarian assistance personnel throughout key Department of Defense organizations.

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LIST OF ACRONYMS AND ABBREVIATIONS

AMC	Air Mobility Command
AOR	Area of Responsibility
C6F	Commander, Sixth Fleet
CENTCOM	United States Central Command
CNO	Chief of Naval Operations
COCOM	Combatant Command
CONUS	Continental United States
CTF-63	Commander, Task Force 63
Denton	Denton Program
DoD	Department of Defense
DoN	Department of the Navy
DoS	Department of State
DSCA	Defense Security Cooperation Agency
EUCOM	United States European Command
FTP	Funded Transportation Program
HA	Humanitarian Assistance
ICAO	International Civil Aviation Organization
JRI	Joint Relief International
N52	Operations Plans and Strategy International Engagement Division
NALO	Navy Air Logistics Office
NCC	Navy Component Command
NGO	Nongovernmental Organization
OHDACA	Overseas Humanitarian Disaster Assistance and Civic Aid
OPNAV	Office of the Chief of Naval Operations
PACOM	United States Pacific Command
PH	Project Handclasp
PHF	Project Handclasp Foundation, Inc.
SAAM	Special Assignment Airlift Mission

SDDC	Surface Deployment and Distribution Command
SMS	Single Mobility System
SOUTHCOM	United States Southern Command
TET	Transportation Exploitation Tool
TP	Transportation Priority
TRANSCOM	United States Transportation Command
TSC	Theater Security Cooperation
USAID	United States Agency for International Development
USC	United States Code

EXECUTIVE SUMMARY

Presidential, national military, individual service, and combatant commander strategic documents all list humanitarian assistance as one of the core goals and responsibilities of the United States armed forces. One part of humanitarian assistance programs is the transportation of nongovernmental organization cargo from the United States to destinations in need. This report analyzes three programs for the transportation of such cargo: the Denton Program, the Funded Transportation Program, and Project Handclasp. The Denton Program and the Funded Transportation Program are employed by the Department of Defense, while Project Handclasp is a Department of the Navy program. All three programs have historically had limited activity to European destinations when compared to other geographic areas of responsibility.

The three programs operate under different legal authorities, funding sources, and operational structures. The Denton Program's legal authority comes from the United States Code for the Armed Forces, Title 10, Section 402. It is funded by the Defense Security Cooperation Agency and United States Transportation Command. The Funded Transportation Program's legal authority comes from the United States Code for the Armed Forces, Title 10, Section 2561, and is funded by the Overseas Humanitarian Disaster Assistance and Civic Aid appropriation. Project Handclasp operates under a Chief of Naval Operations instruction and is funded by the Navy.

The analysis shows that no transportation program currently exists that focuses on providing a quality of service to meet combatant commands' humanitarian assistance transportation needs. Both Denton and the Funded Transportation Program are a public service provided by the Department of Defense to nongovernmental organizations, and are driven by applications to the programs from nonmilitary sources. Project Handclasp is a Navy program, with its current focus primarily on Navy missions.

The analysis outlines the legal, fiscal, and operational mechanisms that may be used to create a program that focuses on providing a quality of service to combatant

commands' humanitarian assistance transportation needs. We also employ an analytical model of space-available transportation to estimate the shipping capacity to European destinations.

The analytical model shows that exclusively space-available transportation is generally insufficient for providing the quality of service that may be required for relationship-building through humanitarian assistance cargo transportation, and that contracted shipping may be necessary. The analytical model further shows only limited improvement of combined space-available transportation and contracting over contracting alone. Moreover, from a policy standpoint, while several options for lead executor of such a program exist, the recommended option is utilizing existing facilities by creating a joint role for Project Handclasp. In this way, Project Handclasp can execute a similar mission for combatant commands as it currently does for the Navy, using several new methods of transport. Project Handclasp has been used by combatant commands in the past; however, operational and organizational hurdles must be overcome before it can serve a clearly defined joint role.

I. INTRODUCTION

A. PROBLEM

For years, nongovernmental organizations (NGOs) from the United States have conducted humanitarian relief operations across the world. In the last several years, the military has become increasingly more involved in providing this type of assistance as well. This is evident in the 2011 release of the National Military Strategy, which emphasizes the importance of building and strengthening international strategic partnerships (Department of Defense, 2011). In order to support these strategic goals, the Department of Defense (DoD) employs two programs, and the Department of the Navy (DoN) operates and maintains an additional program, to ship NGO-owned humanitarian assistance (HA) cargo to countries in need. The DoD programs are the Denton Program (Denton) and the Funded Transportation Program (FTP), and the DoN program is Project Handclasp (PH). All three programs operate independently of each other through different operational guidelines, funding sources, and legal authorities. However, they all work in conjunction with United States government country teams and coordinate through representatives of the United States Agency for International Development (USAID).

In recent years, United States Southern Command (SOUTHCOM) has been very successful in utilizing these programs for cargo delivery to their area of responsibility (AOR). United States European Command (EUCOM), however, has not enjoyed the same amount of success. For example, in 2009, PH delivered 750 pallets of HA cargo, weighing nearly 500,000 pounds, to SOUTHCOM's AOR, but only one pallet was transported to Europe (United States Navy Project Handclasp, 2009). In the same year, FTP shipped just two containers of HA materials to EUCOM, while SOUTHCOM received 49 (Defense Security Cooperation Agency, 2010). Similarly, in fiscal years 2010 and 2011, Denton transported 1,208,962 pounds of cargo to 13 countries in SOUTHCOM. In the same period, only 7,000 pounds were delivered to one country in EUCOM (Joint Relief International, 2011).

B. SCOPE OF STUDY

The main objective of this study is to understand why EUCOM is underserved by the DoD HA transportation programs. A secondary goal of this research is to outline possible policy changes toward a standardized system that can be used by all combatant commanders in order to deliver humanitarian cargo to intended recipients within their respective AORs. In order to provide context to the study, we outline the current operational procedures of the three programs and their governing legal authorities. We then recommend possible policy and operational changes to increase the shipping capacity of HA material to EUCOM and other combatant commands (COCOMs). We also quantify the benefits of these operational and policy changes through an analytical model of HA cargo transportation.

II. OPERATIONAL CONTEXT AND CURRENT PROGRAM OPERATIONS

A. IMPORTANCE OF HUMANITARIAN ASSISTANCE

The 2004 Indian Ocean tsunami was one of the most devastating natural disasters in history, leaving over 200,000 dead and millions homeless in 14 countries. In response, nations from across the world donated over \$14 billion in what some deem the largest disaster relief effort to date (Jayasuriya and McCawley, 2010). This natural disaster and subsequent relief efforts changed the scale of HA, and also changed the approaches and views of the United States government and the DoD toward HA programs. The current EUCOM Commander, Admiral Stavridis states:

As shown by DoD's experience in Indonesia after the 2004 tsunami, aid can produce a significant amount of sustained goodwill toward the United States, and particularly toward its military. Putting a face to the U.S. military, especially when the face is that of a doctor performing surgeries, or that of a SeaBees team building a medical center, can only be a force for improving international relations and creating a positive perception of the United States. (2010, p. 142)

Prior to Stavridis' job as Commander of EUCOM, he held the position of SOUTHCOM Commander, where, in 2006, he initiated several HA missions in South America and the Caribbean. One of the most successful of these operations was Continuing Promise 2007. For this mission, the USNS (United States Naval Ship) COMFORT, a hospital ship, conducted medical missions in 12 countries in Latin America and the Caribbean. The exercise was so successful that it was reinitiated the following year with two amphibious ships—one that was deployed to the Pacific and one to the Atlantic. Altogether, in 2008, the two amphibious ships treated more than 200,000 patients in several countries around the world.

The United States Pacific Fleet developed a similar annual operation in 2006, called Pacific Partnership. It was designed to provide HA to countries in the United States Pacific Command (PACOM) region. In 2010, the Pacific Partnership interagency operation included 10 partner nations, 19 NGOs, USAID, and the United States Public Health Service. As part of that mission, PH distributed over 58

pallets of donated material, worth over \$162,000, to six host nations (L. Franchetti, personal communication, June 30, 2010).

As evidence of the DoD's increasing awareness of the benefits of HA, through missions such as those in South America and the Pacific, the 2011 National Military Strategy emphasizes the importance of strengthening and building international relations through HA operations:

Humanitarian assistance and disaster relief activities employ the Joint Force to address partner needs and sometimes provide opportunities to build confidence and trust between erstwhile adversaries. They also help us gain and maintain access and relationships that support our broader national interests. (Department of Defense, 2011, p. 17)

In order to achieve these strategic goals, all the COCOMs define the necessary steps to build relations in their respective AORs through their Theater Security Cooperation (TSC) plans. Specifically for EUCOM, Stavridis' priorities focus on building and strengthening partnerships with European counterparts:

While ensuring [EUCOM] readiness to execute military operations in support of contingency plans, EUCOM will:

1. Build partnerships to enhance security, regional stability, and support of global initiatives like ISAF [International Security Assistance Force].
2. Strengthen NATO [North Atlantic Treaty Organization] collective defense and assist its transformation.
3. Support operations in Afghanistan and Iraq.
4. Counter transnational threats.
5. Engage Israel, Russia, and Turkey in areas of mutual interest. (United States European Command, n. d., p. 7)

To accomplish these objectives, EUCOM must be able to partner with NGOs to effectively use the HA programs to transport NGO-owned cargo to their intended recipients.

B. CURRENT DENTON OPERATIONS

Denton provides transportation of NGO cargo at no cost to the NGO and is jointly administered by USAID, the Department of State (DoS), and DoD. The program was originally created by Jeremiah Denton, a Senator from Alabama, as an amendment to the Foreign Assistance Act of 1961. Senator Denton created the program to use space-available to deliver NGO cargo to third-world countries. It was not until 1985, however, that the program was implemented (Norman, 2011).

Since Denton is a DoD program, it is governed by the United States Code (USC) for the Armed Forces, Title 10. Specifically, the legal authority for Denton's operations comes from USC 10, Section 402. The law states that, notwithstanding other provisions of law, "the Secretary of Defense may transport to any country without charge, supplies which have been furnished by a nongovernmental source and which are intended for humanitarian assistance. Such supplies may be transported only on a space available basis" (Transportation of Humanitarian Relief Supplies to Foreign Countries, 2011, p. 1). Section 402 continues to describe specific requirements that must be met before material can be accepted for shipment. For example, the material must be in suitable condition, adequate arrangements must be made for its distribution in the destination country, and there must be a legitimate humanitarian need for it. Section 402 concludes with a yearly reporting requirement to Congress for any cargo shipped using the legal authority provided.

Since Denton uses strictly space-available on military assets, the costs to the DoD are minimal; however, some funding is necessary to administer and facilitate cargo movement. Much of this work is done by the United States Transportation Command (TRANSCOM) contractor Joint Relief International (JRI). The funding for JRI is covered by TRANSCOM and the Defense Security Cooperation Agency (DSCA) (P. Marshall, personal communication, July 7, 2011).

In order to meet each of the requirements in USC 10, Section 402, Denton has a specific operational procedure for NGOs to follow, which is outlined in Chapter 12 of DoD Instruction 5105.38-M. First, the NGO donor contacts USAID and fills out an online application. USAID then coordinates approval of the application with DoS and

DSCA. However, before any material is accepted, the donor must complete the necessary customs paperwork, obtain a duty-free letter, and identify a legitimate consignee of the material in the destination country, as per Section 402, before their application can be approved by Denton. Additionally, the material must be properly packaged and a suitable space-available route from the cargo's origin to its final destination must be identified by the JRI contractor. If no such route exists, the cargo is not accepted because it cannot be transported. The NGO must assume all costs associated with customs, packaging, and cargo delivery to the time and place of embarkation (Defense Security Cooperation Agency, 2003).

Once an application is accepted and a space-available route is identified, the process of moving the cargo can begin. Joint Relief International (JRI) uses the TRANSCOM Single Mobility System (SMS), an online tracking system containing primarily military aircraft data, to find available transportation channels. While SMS has some functionality targeted specifically at Denton, no automated system exists for finding space-available routes. To facilitate a shipment, JRI contractors must manually search possible routes to determine likely space-available channels to the destination. Accepted NGO cargo is classified as Transportation Priority 4 (TP-4) cargo, which is the lowest cargo classification level in terms of priority in the DoD logistics system. JRI is able to track the cargo electronically, using a Transportation Cargo Number on the Global Air Transportation Execution System and on a system called Integrated Data Environment/Global Transportation Network Convergence, as well as through personal communications between JRI and personnel at transshipment locations. JRI tracks the cargo until its final destination, where USAID representatives, as well as United States military personnel involved with the cargo's transportation, coordinate with a prearranged consignee to properly distribute the donations to the intended recipients (K. Hundemer, personal communication, June 28, 2011).

Denton cargo can be shipped quickly on a well-utilized, space-available route once the cargo is accepted. For example, the process typically takes less than a week—and usually no more than two weeks—for cargo travelling through Ramstein Air Force Base in Germany to its ultimate destination (D. Noe, personal communication,

June 2, 2011). However, the application process for cargo acceptance can take time, and material is not always guaranteed to be accepted due to various aforementioned reasons.

At its core, Denton is designed to be a public service offered by the DoD to NGO donors, who drive the process through their initial applications. Although the donors must cover some incurring costs and complete the required paperwork prior to material acceptance, the program offers the NGO donors a benefit by providing transportation at no cost. Denton realizes this, so, in order to avoid being inundated with requests from a single NGO, they have implemented policies to be fair to all NGOs. For example, the program will typically accept only one shipment per NGO at a time.

Legally, Denton can use space-available pallet positions on any military asset for transportation. However, the Navy and other services do not use SMS for tracking, so Denton has limited visibility of Navy shipping and space available on aircraft other than that of the Air Force. As a result, Denton only uses Air Force channel, contingency, and Special Assignment Airlift Mission (SAAM) flights for space-available cargo transportation.

There are several reasons for the limited use of Denton in the EUCOM AOR, compared to other AORs. One reason is that shipment applications are initiated by NGOs. Without NGO applications with a European destination, no material can be delivered to Europe. The lack of applications for European destinations is due to several factors. First, NGOs often donate material in response to perceived high poverty levels or a natural disaster, such as the earthquake that devastated Haiti in 2010. Thus, a large number of NGOs apply for transportation to the SOUTHCOM or PACOM AORs because of their countries' high susceptibility to these types of disasters and their perceived poverty levels. Second, SOUTHCOM and United States Central Command (CENTCOM) have a much higher frequency of inbound DoD transportation assets than EUCOM, due to the proximity of SOUTHCOM to the United States and the high number of contingency missions flying to CENTCOM to support the war efforts. As a result, NGOs take advantage of these opportunities and apply for delivery to countries within the aforementioned AORs instead of to EUCOM, where the main countries of interest have a much lower frequency of available DoD transportation channels. A Denton

application for transportation to these remote European locations may be rejected because potential suitable delivery routes cannot be found. The drawdown of operations in Iraq and Afghanistan will further reduce the number of space-available pallet positions to European destinations because, typically, Denton cargo transported to Europe utilizes contingency missions that are maintained in order to support the efforts in Iraq and Afghanistan (K. Hundemer, personal communication, December 10, 2011).

A final limiting factor to Denton operations is staffing. Although JRI utilizes computer systems, such as SMS, to identify available routes, cargo delivery and mission success are ultimately reliant on person-to-person coordination and networking in order to find space available in a timely fashion. The process is by no means automated. Additionally, verifying NGO requests, finding space-available routes, and tracking shipments can be a labor-intensive process that is often limited not necessarily by lack of space-available transportation, but rather by a limited amount of manpower. As a result, if difficult-to-identify-and-administer space-available routes do exist, they may remain unutilized.

C. CURRENT FUNDED TRANSPORTATION OPERATIONS

FTP also provides transportation for NGO-owned cargo at no cost to the NGO. The program is administered by DSCA, and the program derives its legal authority through USC 10, Section 2561. The section states “funds authorized to be appropriated to the Department of Defense for . . . humanitarian assistance shall be used for the purpose of providing transportation of humanitarian relief and for other humanitarian purposes worldwide” (Humanitarian Assistance, 2011, p. 1). It concludes with an explanation of the annual reporting requirement to Congress for any funds that are used for humanitarian relief and humanitarian cargo transportation missions funded by the DoD.

Funds for FTP and several other programs are provided yearly by the Overseas Humanitarian Disaster Assistance and Civic Aid (OHDACA) appropriation. FTP receives a variable amount each year that usually totals approximately \$1.5 million to be used for all FTP transportation worldwide.

Operationally, FTP is similar to Denton. In both cases, the process is initiated by an NGO submitting an application. In the case of FTP, the application is handled by DSCA. The NGO application and cargo for FTP have the same requirements as Denton: the cargo must have a legitimate humanitarian purpose, it must be packaged properly, customs paperwork with a duty-free letter must be completed, and a consignee of the material in the destination country must be identified and verified before the application is approved (Funded Transportation Program, 2011). Because FTP purchases transportation for the cargo from outside contractors, route identification is not a necessary step. The funds required for transporting a specific NGO request can be estimated using the TRANSCOM SMS. Applications are accepted on a first-come, first-served basis until the yearly funding is exhausted.

At its core, FTP is essentially an extension of Denton, intended to reach destinations that are not accessible to space-available transportation assets. Similar to Denton, FTP is a public service by the DoD to NGOs. In the past, the two programs have been administered by DSCA, which accounts for their similar operational requirements. NGOs also drive the FTP process through their initial applications, as is the case with Denton.

FTP derives its authority from USC 10, Section 2561; however, it is not the only expression of that authority. Section 2561 allows DoD to use correct appropriations for humanitarian purposes, but does not contain the explicit requirements of Section 402, the Denton amendment. Thus, it is possible for other programs to exist under Section 2561 that do not explicitly follow the Denton model of transport. In particular, Section 2561 does allow for HA programs that are not driven by an NGO request for transportation to a predetermined consignee.

FTP's underutilization in EUCOM, as compared to other AORs, is a result of several factors. First, similar to Denton, if no NGO applications requesting shipment to European destinations are submitted, then no material is transported to EUCOM by FTP. Second, because FTP is a public service to NGOs and operates on a first-come, first-served basis, delivery locations are a result of NGO requests, and there is no expectation of an even distribution of HA material among AORs. Third, for destinations in former

Soviet republics of Eastern Europe, the DoS funds a similar program administered through Counterpart International that services some NGO demand for Europe (Counterpart International, 2012). Finally, FTP is limited by funding appropriated by Congress. Once the funding for the fiscal year is exhausted, the program cannot make further shipments.

D. CURRENT PROJECT HANDCLASP OPERATIONS

PH is a DoN program, implemented by the Chief of Naval Operations (CNO) in 1962 to support Navy humanitarian missions. PH is governed by a CNO instruction that outlines its mission and operational goals. Its primary purpose is to enhance the perceptions of the United States and the Navy through direct, person-to-person contact between United States Navy and Marine Corps personnel and people overseas. PH may also arrange for space-available transportation of NGO material to consigned recipients overseas, as long as that material fits into the categories outlined in the instruction. PH falls under the direction and strategic guidance of the Office of the Chief of Naval Operations (OPNAV) for Operations Plans and Strategy International Engagement Division (N52). OPNAV N52 is the program sponsor and is responsible for the PH instruction. Consequently, PH provides quarterly reports to OPNAV N52 measuring program performance and providing updates on administration, expenses, and manning.

Since PH is a DoN program executing a Navy mission, its operations are funded by DoN. In recent years, some COCOMs have assigned their personnel to assist PH in enhancing its ability to deliver material to the COCOMs' AORs. For instance, SOUTHCOM previously sent an officer to PH to facilitate the delivery of HA supplies to SOUTHCOM, and an officer from EUCOM is currently assigned to a similar position at PH for the EUCOM AOR.

The operations of PH are facilitated by two separate legal entities. The first is itself, and the second is a nonprofit NGO called the Project Handclasp Foundation, Inc. (PHF). The PH transportation process begins with a donation to PHF from a corporation, a public service organization, or an individual. PHF assumes legal title of the material once it is donated.

While legal title to the material is held by PHF, PH is operationally in charge of receiving, collecting, inspecting, consolidating, storing, and transporting the donated material.

Donated material falls under two distinct categories: consigned or unconsigned. Consigned donations have a particular recipient or geographic area targeted by the donor. According to the PH instruction, consigned material is only accepted if the donor's objectives contribute to the overall mission of PH (Office of the Chief of Naval Operations, 2006). For consigned material, PH provides transportation strictly on a space-available basis and the donor arranges for distribution to the identified consignee. In contrast, unconsigned donations are essentially goodwill material that can be used at the discretion of PH.

PH receives donations and is able to store them in a warehouse in San Diego with capacity for approximately 3,000 Navy pallets (15 feet long by 18 feet wide). Following the CNO instruction, the material is properly inspected and often repackaged to meet transportation requirements. The material is then stored in the warehouse until an appropriate Navy mission is identified for the material's overseas distribution. To identify destinations for unconsigned material, Navy Component Commands (NCCs) communicate their HA needs to PH, who then arranges for transportation and distribution as necessary. Throughout the entire process for both consigned and unconsigned material, PHF maintains the legal title to the donations; the Navy never legally owns donated material.

PH does not use a centralized system, such as SMS, to find space-available transportation. Rather, they have access to Navy schedules through direct contact with fleet commanders. PH also tracks shipments through direct communication with ships' crews. Recently, PH has been part of a number of Navy missions, including Continuing Promise and Pacific Partnership. In addition to the warehouse in San Diego, PH has access to several forward-deployed staging areas that can store 20 to 100 Navy pallets. These staging areas are typically used to hold supplies for unforeseen disaster relief operations. Occasionally, as a secondary mission, they can be used for short-term storage to facilitate transportation.

One such staging area is located in the EUCOM AOR in Rota, Spain. Others are located in Pearl Harbor, Hawaii; Norfolk, Virginia; Mayport, Florida; Singapore; and Yokosuka, Japan.

At its core, PH is a Navy program, funded by the Navy, and executing a Navy mission. As such, PH only has the authority to use Navy space-available assets. PH's transportation ability is limited by ship schedules, which are often unreliable and much more infrequent than the Air Force aircraft routes used by Denton. The program is also labor-intensive and limitations are not necessarily the result of a deficiency of space-available opportunities, but rather a limit on the manpower that is necessary to maintain private partner relationships and take advantage of transportation opportunities.

PH contrasts with the other two programs in one key area: both Denton and FTP are a public service by the DoD, driven by NGO requests for transportation, whereas PH is driven by Navy mission requirements to improve the perception of the United States Navy overseas. As an explicit example, PH can receive unconsigned donations and distribute them based on NCC requirements. Once transported, the unconsigned PH material is ultimately distributed to the recipient by uniformed Navy or Marine Corps personnel.

PH's distribution of HA material in the EUCOM AOR has been limited. The main reason is PH's inability to use anything other than Navy assets, particularly space available on ships. The countries to which EUCOM strives to provide HA typically do not have regularly scheduled ship port visits. Thus, the opportunities for PH to schedule cargo deliveries are infrequent. EUCOM is also at a disadvantage because scheduled humanitarian missions, such as Pacific Partnership and Continuing Promise, do not occur in their AOR. These operations carry large amounts of PH material—for example, in 2009, the Continuing Promise mission accounted for 425 Navy pallets of SOUTHCOM's total 750 pallets from PH. Such missions historically have not occurred in EUCOM because these types of operations are often initiated in response to a natural disaster, in the case of Pacific Partnership, or to aid developing countries, as with Continuing Promise. Europe typically does not have the same disaster-related and economic challenges faced by countries within the SOUTHCOM and PACOM regions. However,

strategically, building and maintaining relationships is as important in Europe as it is in other regions of the world.

Finally, a critical component of having effective HA transportation programs is to deliver cargo that satisfies a need at the destination. EUCOM has been at the forefront of initiating a *pull* transportation system, where cargo is only shipped if it satisfies an identified requirement at the destination, as opposed to a *push* transportation system, where cargo is shipped if it is available and the channel exists. Cargo pushed through the transportation system increases raw pallet numbers, but it often decreases the effectiveness and image of HA transportation programs because it remains unused after arriving at its destination. Denton and FTP address this issue by requiring a predetermined consignee to the material. PH also tries to utilize the *pull* model by shipping material in response to NCC requests. These requests are based on country needs within their respective AORs.

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III. LITERATURE REVIEW

The area of humanitarian logistics has been a subject of intense study in the past decade due to a high frequency of natural disasters around the world. Most of the research, however, has been conducted on logistical challenges associated almost exclusively with disaster relief operations. Some of these studies suggest qualitative policy recommendations, while others approach the problem quantitatively. Our study applies both qualitative research to make policy recommendations and a quantitative model that offers insight on the benefits of using different types of transportation. The main difference between our study and the following research is that we address the problem of long-term, sustained humanitarian aid operations rather than disaster relief missions, which are operationally and logistically different. Specifically, we consider options using all types of space-available transportation for humanitarian cargo using a stochastic optimization model.

Salmeron, Kline, and Densham (2011) conduct a study that most closely relates to our problem of long-term, sustained HA and transportation of HA cargo. The study focuses on using Navy maritime assets for HA. It applies an optimization model to ship scheduling in order to determine the most effective deployment schedules that fulfill overseas humanitarian needs. Our model also considers space available on Navy ships, but we take a more holistic approach, looking at all military assets as well as contract transportation for cargo delivery.

Oloruntoba and Gray (2006) also consider the problem of long-term developmental HA operations. They distinguish between this type of HA and emergency relief, emphasizing the importance of supply chain agility to address these differences. They approach the problem qualitatively offering overarching policy recommendations for humanitarian sector principles, notably a more business-like approach to supply chain management. This concept of flexibility within supply chain humanitarian logistics relates to the scope of our study in that it acknowledges that the problem of long-term, sustained development needs to be addressed differently from emergency relief operations.

Thomas and Kopczak (2005) also take a qualitative approach to the problem of HA. Like most of the research we found, their focus is on disaster relief operations. However, they identify core challenges, such as inadequacies in technology and professional training, which are common among all humanitarian sector operations. They offer nonquantitative solutions in the context of supply chain management to include developing a professional logistics community, standardizing training, and providing meaningful metrics to measure performance, as well as adapting new technology.

Similarly, Lin, Batta, and Rogerson (2009) and Van Wassenhove and Martinez (2010) address the problem of disaster relief. However, more similar to our approach, they offer solutions using quantitative operational research techniques. Lin et al. (2009) apply an optimization model to the problem of humanitarian relief logistics, specifically in response to an earthquake. They use an integer programming model to determine optimal depot location and number of vehicles while minimizing cost. To create a realistic disaster scenario, they simulate the earthquake using a software program developed by the Federal Emergency Management Agency that analyzes losses from natural disasters. Likewise, Van Wassenhove and Martinez (2010) apply a stochastic optimization model to last mile operations to determine optimal vehicle fleet size for relief missions after a disaster occurs.

Salmeron and Apte (2010) also apply a stochastic optimization model to disaster relief operations. Their model differs from ours in that it is a two-stage model, where the first phase focuses on the longer-term problem of resource allocation before the disaster happens. This part of the model aims to minimize casualties by appropriate use of resources, such as warehouses, medical facilities, and shelters. The second phase of the model addresses more immediate logistical concerns, such as providing appropriate relief with available transportation assets and resources after the disaster has occurred.

Stochastic optimization proves to be a useful technique in analyzing all types of HA problems because of the high amount of uncertainty that occurs in all phases of HA operations. Salmeron and Apte (2010) incorporate stochasticity by modeling high-probability scenarios. Since our model does not deal with disaster-driven scenarios, we

incorporate randomness in way similar to Evans (1976). He uses a stochastic maximum flow model to obtain an expected value of max flow of a network with random arc capacities. We use a similar model, in which we obtain the expected value by sampling from a probability distribution and running the model multiple times.

Although we use a similar quantitative stochastic optimization modeling approach to most HA research, our study differs from existing literature in the type of problem that it addresses. We attempt to solve only the problem of providing long-term, sustained, developmental HA, as opposed to disaster relief. These are two fundamentally different problems that need to be addressed in two distinct ways. The problem of disaster relief is characterized by short-term, massive response. Logistically, it involves moving a large amount of supplies in a short amount of time. In contrast, developmental humanitarian aid operations typically are more long-term and involve the delivery of a smaller amount of materials over a sustained period of time. As a result, our model differs from most HA studies that are tailored toward disaster relief. We also look at the option of space-available cargo transportation using military assets. To the best of our knowledge, we are the first to create a holistic logistical model for space-available transportation routes. Especially, in the context of DoD HA programs, this research is the first to analyze the aforementioned long-term, peacetime operations, as opposed to disaster relief operations.

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IV. DATA AND METHODOLOGY

A. DATA

The inputs for our model are organized in two separate files: one pertaining to *nodes* for the model and their associated data, and the other containing information regarding the model's *arcs*. Table 1 shows a sample of the node file:

Table 1. Sample of the node data file that provides inputs for our networks model.

NodeName	ICAOs	Country	Port	Source/Sink	Lat/Lon
PearlHarbor	PHIK	U.S.	Y	Source	21.32/-157.92
DallasTexas	KDFW	U.S.	N	Source	32.90/-97.04
Montenegro	LYBR LYNI LYPG	MON	Y	Sink	43.00/20.37
Sigonella	LICZ LLIC	IT	Y	Neither	37.40/14.92

There are three types of nodes in our model: cargo origins in the United States, transshipment nodes, and cargo destinations in Europe. With each node, we associate several pieces of data, which are displayed as columns in the node data file:

NodeName: Unique name to identify the node.

International Civil Aviation Organization (ICAOs): Four-digit codes for relevant airports. Since a node may represent a country, there may be more than one ICAO code per node to represent the multiple airports in that country.

Country: Country in which the port is located.

Port: Whether the location is an established shipping port or not.

Source/Sink: Whether each node is an origin node (*Source*), an intermediary node (*Neither*), or a final destination node (*Sink*).

Lat/Lon: The latitude and longitude of each node.

Table 2 shows a sample of the arc data that is used for our model inputs:

Table 2. Sample of the arc data file that provides inputs for our networks model.

StartNode	EndNode	ShippingType	Cost	Capacity/Probability
CherryPoint, NorthCarolina	Norfolk	AF Air	28.95	1/0.007;0/0.993
Marseille	Sigonella	AF Air	131.84	1/0.007;0/0.993
Palermo	Taranto	Ship	0.00	1.5/0.008; 0/0.992

StartNode: Starting location of each arc.

EndNode: Ending location of each arc.

ShippingType: Type of shipping associated with each arc. Four shipping types are used in the model: Air Force (AF) Air, Navy Air, Navy Ship, and Contract.

Cost: Cost data in dollars per Air Force pallet for transporting across the edge. Cost data is only applicable for Air Force air and Contract transportation types. All other shipping types have a cost of zero because the HA programs can ship for free using both Navy ships and Navy aircraft because of different space-available models across services.

Capacity/Probability: Pairs of numbers describing the capacity of a particular arc and the probability of that capacity (of Air Force pallets) being available. This probability distribution is based on a two-week period. We use this amount of time because this is the longest amount of time that Denton cargo typically stays in one place before being shipped to its ultimate destination. A “1/0.25; 0/0.75” in this column can be interpreted as a 25% chance of the arc having a capacity of one Air Force pallet and a 75% chance of the arc having a capacity of zero pallets in a two-week period.

We automatically populate these two input files by using several spreadsheet manipulation and programming techniques on the following the data sources.

1. Sixth Fleet Ship Port Visit Data

We use three years’ worth of historical data on all Navy ship port visits in Europe from Commander, Sixth Fleet (C6F) to derive capacity and probability distributions for Navy ship routes in our model. In those three years, 115 Navy ships conducted port visits within this AOR. Table 3 shows a sample of the port visit data:

Table 3. Sample of data from C6F on Navy ship port visits in Sixth Fleet from 2008 until 2011.

Name	Hull	Event Type Name	Port Name	Country Name	From	Until	PVST Length	Year
THE SULLIVANS	DDG-68	PVST	VARNA	BULGARIA	2/5/07	2/8/07	4	2007
DONALD COOK	DDG-75	PVST	VARNA	BULGARIA	7/6/07	7/7/07	2	2007

The data includes the following information:

Name: Name of the visiting vessel.

Hull: Class and hull number of the ship. The class of ship is important because we associate different capacities with different classes of ship. We have a separate data file with these capacities that provides typical space available on each ship class.

Event Type Name: Purpose of the vessel's visit to the particular port. In the given example, *PVST* means that the vessel was conducting a routine port visit.

Port Name: Name of the port.

Country Name: Country in which the port is located.

From: Date the ship arrived at the port.

Until: Date the ship departed the port.

PVST Length: Number of days the ship remained in port.

Year: Year of the port visit.

2. Navy Air Logistics Office Commander Task Force 63 Data

We obtain similar data from Navy Air Logistics Office (NALO) located at Commander, Task Force 63 (CTF-63) in Naples, Italy. These data contain flight information on all Navy aircraft movement within Sixth Fleet for fiscal years 2008 through 2011, which totals to 2,519 flight legs. Table 4 shows a sample of these data:

Table 4. Sample of data from NALO on all Navy aircraft movement within Sixth Fleet from 2008 until 2011.

A/C	StartDate(Z)	EndDate(Z)	Itinerary
C26	12-Oct-07	13-Oct-07	LIRN LGSA LIRN
C26	21-Oct-07	24-Oct-07	LIRN LEMO LIRN
C26	1-Oct-07	2-Oct-07	LIRN LPPT LIEO LIRN

Aircraft (A/C): Identifier of the aircraft flying the mission.

StartDate(Z): Date the aircraft departed for the mission (in zulu time).

EndDate(Z): Date the aircraft returned from the mission (in zulu time).

Itinerary: List of all airports to which the aircraft flew during the mission, by ICAO code.

In the case of these NALO flights, we assume each aircraft has two available pallet positions. This is greater than the amount of space-available we assume for Air Force flights as a result of conversations with CTF-63 personnel, who said they typically do have some pallet positions available for cargo on their aircraft.

3. Single Mobility System Data

The majority of the data is taken from TRANSCOM SMS. SMS collects data from a variety of transportation computer systems to create a database with cargo and passenger movement of both contract and Air Force air, sea, and land transportation assets. From this database, we extract data pertaining only to Air Force missions flown to airports in the 17 destination countries in EUCOM AOR within the past three years. The data contains 47,324 flight legs. Table 5 is a sample of this data:

Table 5. Sample of SMS data on Air Force missions to the 17 destination countries in Europe from 2008 until 2011.

ACMDS	DATE-TIME	ICAO	Itinerary	Mission Number	Mission Type
B76730	28/JUN/2011 0138	EDDP	KDFW EDDP OKBK EDDP KDFW	BAM101626177	SAAM
DC0103	15/SEP/2011 0103	LIPA	KBWI ETAR LIPA LIPZ OTBH LIPA LIPZ ETAR KBWI	BKWVLY600258	CHANL
KC10A	15/MAR/2011 1430	ETAR	KWRI KDOV EGUN ETAR OTBH LEMO KWRI	6BW45Y50B073	CHANL
B74720	14/AUG/2011 2050	EBLG	KDOV EBLG LTAG	BBR6X390A226	CHANL

Aircraft Mission, Design, Series (ACMDS): Aircraft identifier.

DATE-TIME: Date and time for the arrival or departure of the aircraft at that particular ICAO.

ICAO: Same as in Table 1.

Itinerary: List of all the airports at which the aircraft made a stop on this particular mission.

Mission Number: Unique identifier for the mission. This code is used to track the flight from origin to destination, across the entire itinerary.

Mission Type: Type of mission. The most common types are “channel” and “contingency.” Channel flights are routes scheduled to run at a normal frequency from airfield to airfield, whereas contingency missions are not regularly scheduled. Contingency missions are missions arranged by an organization—military or nonmilitary—for a specific mission.

We automatically identify most of the relevant nodes for the model using the SMS data because it contains the most DoD transportation missions to the greatest number of locations. We exclude several nodes in the Middle East and other nodes that are out of the scope of EUCOM AOR. The Middle East locations that are excluded from

the model are those that are normally on aircraft contingency routes. These contingency missions to the Middle East are primarily support for Operation Enduring Freedom and Operation Iraqi Freedom operations that do not typically carry HA TP-4 cargo because they are loaded with higher priority TP-1 and TP-2 cargo and personnel. The information associated with these flight missions is beyond the scope of our model.

4. Cost Data

The cost information in our arc data has been obtained from several sources. The first is from the Air Force Air Mobility Command's *AMC Air Channel Sequence Listing* document. This document contains cost rates per cubic foot for TP-4 cargo transport. We perform a simple regression on these data points in order to obtain an average cost per pallet per mile, which is approximately twenty cents, for aircraft transportation to EUCOM AOR.

In addition, we obtain an average cost of shipping a container from the United States to Europe by contract shipping from 715 contract cost estimates from the Surface Deployment and Distribution Command (SDDC). These data contain detailed information on rates for moving cargo via shipping between ports worldwide. Also from SDDC, we have data containing rates for shipping cargo by ground between various locations. These rates are tiered according to amount of mileage. For example, 0–50 miles may have one cost per mile, while 50–100 miles would have a different cost. These costs vary by country. For each distance tier, we average the costs across European countries to obtain an average cost for that distance tier. We compute the great circle distance between two European nodes, and use the corresponding average tier cost to derive the cost of transportation between the nodes.

B. BASIC MODEL

We use a stochastic, maximum flow optimization formulation to model transporting cargo from the origins to the destinations. Our basic model is as follows:

Sets:

N : set of all nodes	[~100]
O : set of origin nodes	[~30]
D : set of destination nodes	[~20]
A : set of all arcs	[~10,000]
Ω : set of transportation scenarios	[~3 ^{10,000}]

Indices:

i, j : nodes

Data:

s_i : relative importance of destination i (no units)
 $\tilde{u}_{ij}(\omega)$: capacity of edge ij under scenario ω (Air Force pallets)
 c_{ij} : cost for shipping on arc ij (dollar per Air Force pallet)
 b : transportation budget per scenario time period (dollars)
 $p(\omega)$: probability of scenario ω

Variables:

y_{ij}^ω : flow on arc ij under scenario ω (Air Force pallets)
 v_i^ω : cargo entering or leaving the system at node i (Air Force pallets)
 $\tilde{z}(\omega)$: weighted cargo transported under scenario under ω (weighted Air

Force pallets)

Formulation (for a given scenario $\omega \in \Omega$):

$$\tilde{z}(\omega) = \max_{y^v} \sum_{i \in D} s_i v_i \quad (1)$$

$$\text{s.t.} \quad \sum_{(i,j) \in A} y_{ij} - \sum_{(j,i) \in A} y_{ji} = -v_j \quad \forall j \in O \quad (2)$$

$$\sum_{(i,j) \in A} y_{ij} - \sum_{(j,i) \in A} y_{ji} = v_j \quad \forall j \in D \quad (3)$$

$$\sum_{(i,j) \in A} y_{ij} - \sum_{(j,i) \in A} y_{ji} = 0 \quad \forall j \in N, j \notin O, j \notin D \quad (4)$$

$$\sum_{(i,j) \in A} c_{ij} y_{ij} \leq b \quad (5)$$

$$y_{ij} \leq \tilde{u}_{ij}(\omega) \quad \forall ij \in A \quad (6)$$

$$y_{ij} \geq 0 \quad \forall ij \in A \quad (7)$$

$$v_j \geq 0 \quad \forall j \in O \cup D \quad (8)$$

The objective function (1) maximizes the importance-weighted cargo flow to destination nodes in the model. The s_i used are notional and do not reflect actual values used by C6F. Constraint (2) stipulates that v_j cargo enters the system in origin node j . Constraint (3) stipulates that v_j cargo leaves the system in destination node j . According to Constraint (4), for all nodes that are neither origin nor destination, the number of pallets arriving to the node must be equal to the number of pallets leaving the node. Constraint (5) is a cost constraint requiring that the total cost spent for transportation over all arcs is less than the transportation budget b . Constraint (6) specifies that for each arc ij , the number of pallets traversing the arc must be less than or equal to the random capacity \tilde{u}_{ij} associated with the arc. Finally, Constraints (7) and (8) are non-negativity constraints for the number of pallets moving from node i to node j and the amount of cargo entering and leaving the system at any origin or destination.

C. RANDOMNESS AND SCENARIO GENERATION

The difference between our model and a typical maximum flow network model is the stochastic capacities on the arcs. We incorporate randomness into our model by using the pairs (capacity, probability) from the arc data as a capacity probability distribution for $\tilde{u}_{ij}(\omega)$. To evaluate the effectiveness of the transportation system, we sample the capacity values from our probability distribution from our arc data for each edge. The result of the model using one of these samples is $\tilde{z}(\omega)$, the objective function representing cargo flow for a two-week period. By running the model 1,000 times with a different sample each time and taking the average, we obtain an estimate of the expected shipping capacity for the network.

We evaluate four different modes of operation for the transportation network: Navy space-available only, Air Force space-available only, contracted delivery only, and all modes combined. For each of the four modes of operation, we analyze the network's ability to move cargo from the United States to each of the 17 countries of interest in the EUCOM AOR. Our results are based on a total of 68 evaluations of the model in Section VI.B, each differing based on the available arcs, as specified by the mode of operation, and the importance parameters, as specified by the destination country of interest. For

each evaluation, the cargo is allowed to originate in any part of the United States, but must use only transportation edges allowed in the scenario, and must be delivered to the destination country of the scenario.

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V. RESULTS AND ANALYSIS

A. MODEL RESULTS

Figures 1 through 4 show the network and all available channels for both sea lanes and air routes originating in the continental United States (CONUS) and arriving in 1 of the 17 destinations to which EUCOM provides HA.

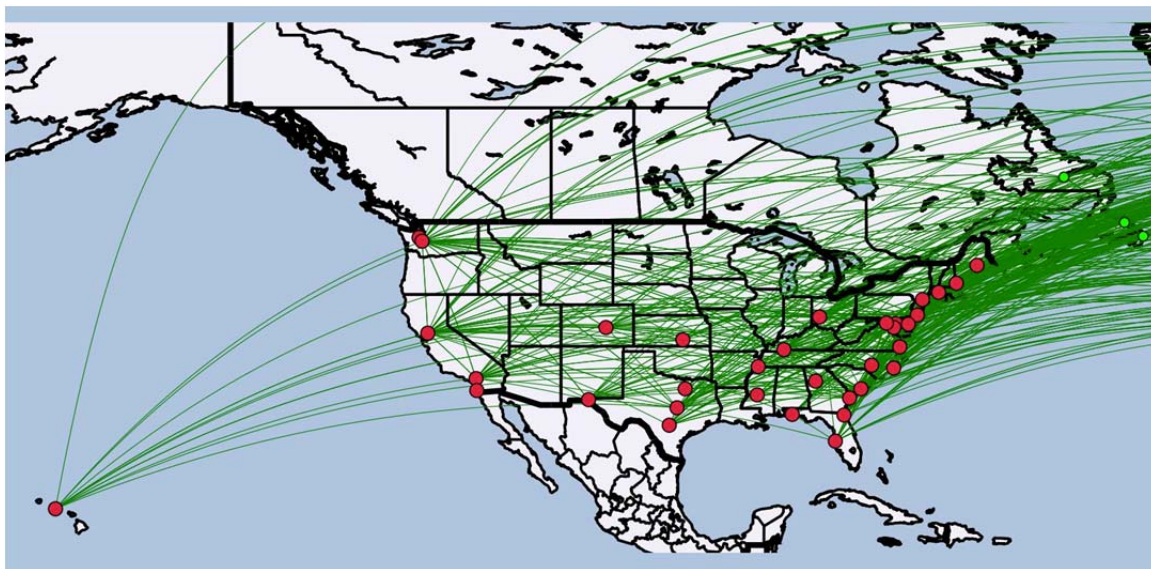


Figure 1. A map of all Air Force aircraft routes in the model originating from the United States. Red dots represent possible cargo origins, green dots represent transshipment locations, and the green edges represent an aircraft route identified from SMS data.

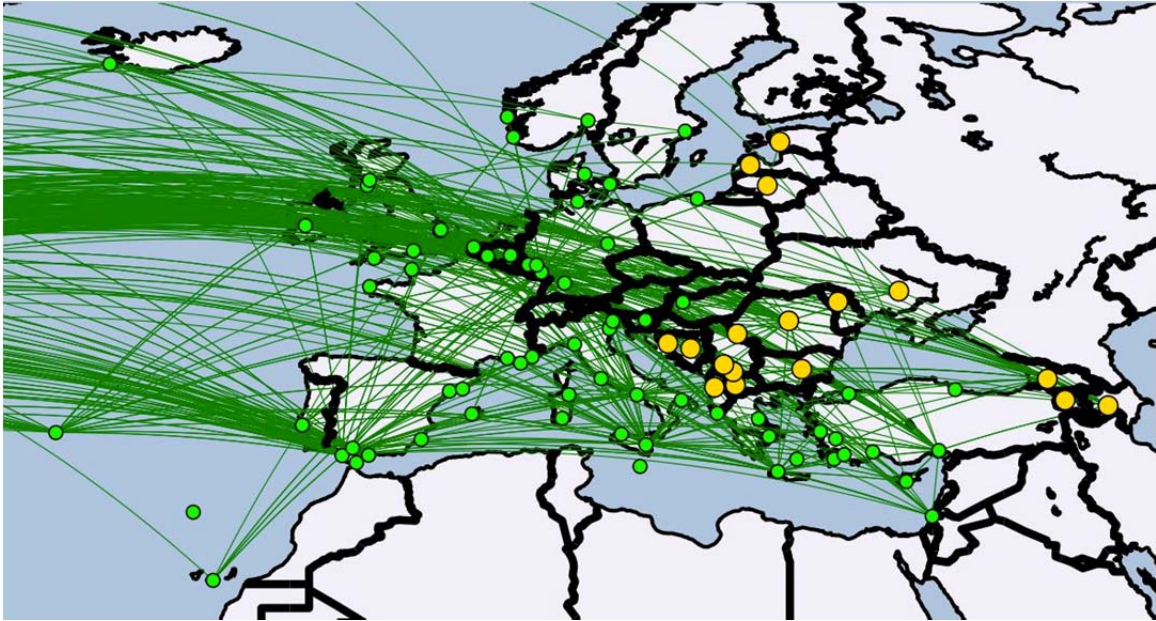


Figure 2. A map of all Air Force aircraft routes in the model arriving in Europe. Green dots represent transshipment locations, yellow dots represent destination nodes, and the green edges represent aircraft routes identified from SMS data.

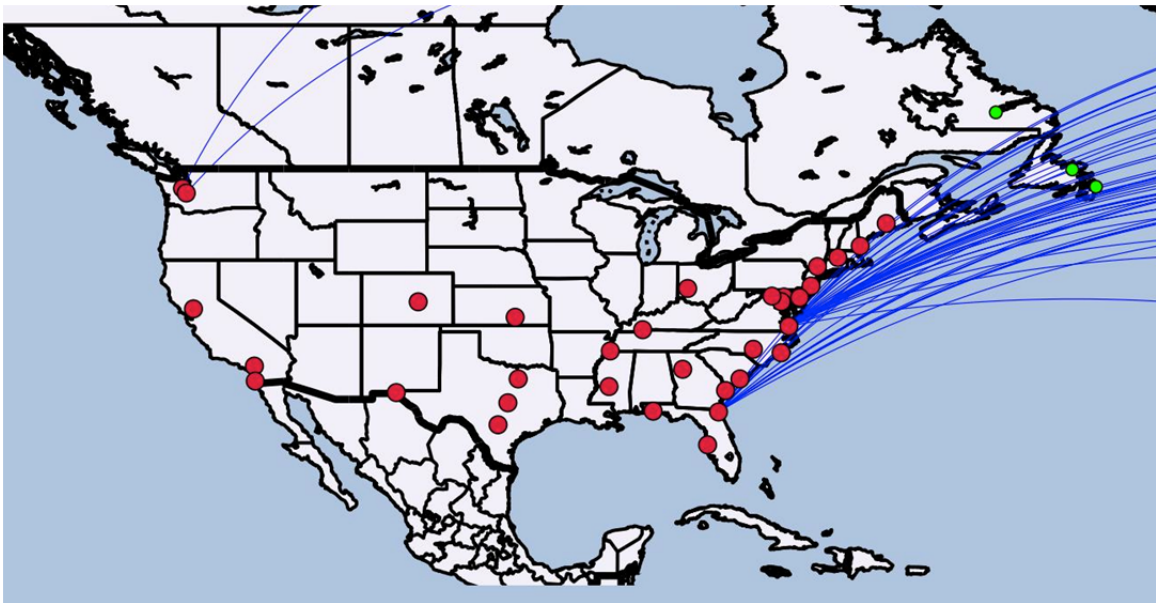


Figure 3. A map of all Navy routes in the model originating from the United States. Red dots represent cargo origins, green dots represent transshipment nodes, and blue edges represent routes identified from C6F or NALO data.

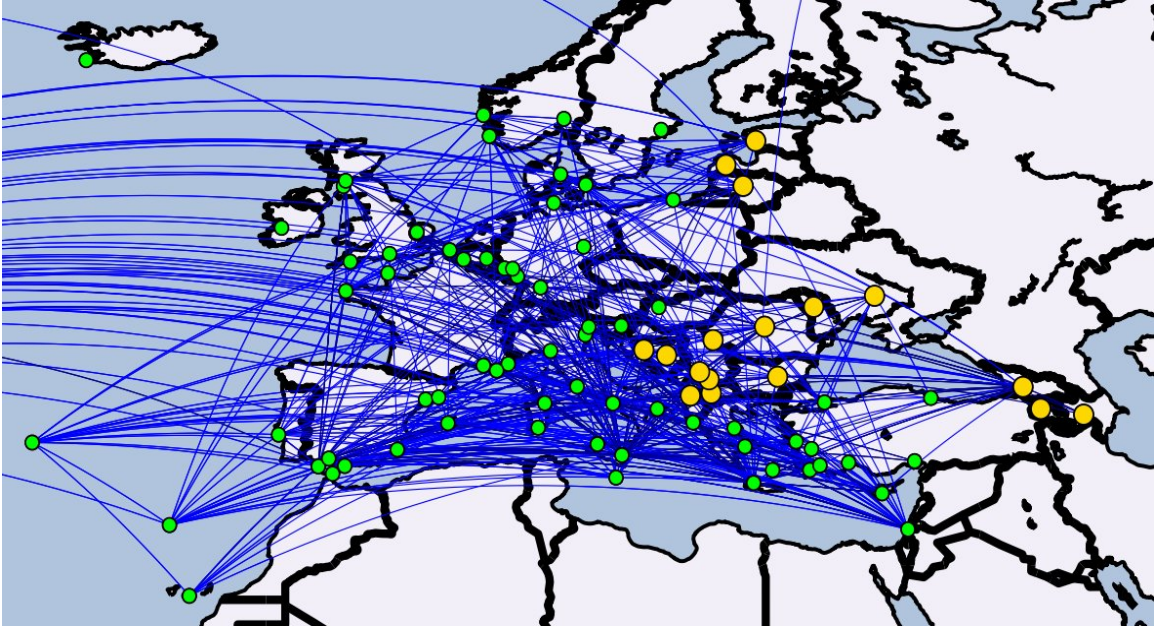


Figure 4. A map of all Navy routes in the model arriving in Europe. Green dots represent transshipment nodes, yellow dots represent destination nodes, and blue edges represent routes identified from C6F or NALO data.

We divide the available logistic channels into three categories—Navy channels including Navy ships and NALO flights, Air Force aircraft channels, and contract channels—and create a logistic model for each kind of transportation. A Navy channel-only network models transportation that only uses space available on Navy assets. An Air Force channel-only network models transportation that only uses space available on Air Force aircraft. A contract channel-only network models cargo movement using only contracted transportation. Finally, we create a fourth network that models combined operations of all three modes of transportation.

We analyze several logistic scenarios. For each of the four networks, we analyze the network’s ability to move cargo from the United States to each of the 17 countries of interest in the EUCOM AOR, for a total of 68 evaluations of the model. In each scenario, the cargo is allowed to originate in any part of the United States, but must use only transportation edges allowed in the scenario, and must be delivered to the destination country of the scenario.

Figure 5 visually depicts one such scenario, transporting cargo to Montenegro using only space available on Air Force aircraft. For this scenario, the model shows that,

on average, space available on Air Force aircraft is able to support approximately 0.45 pallets per two-week time period. This is an average shipment amount per unit time, and operationally translates into the ability to ship a single pallet about every month and a half. The model also identifies the legs from McGuire to Ramstein, Dover to Ramstein, Bangor International to Ramstein, and Ramstein to Montenegro as the essential channels for delivering this cargo. In the diagram, these types of channels with a high reliability are shown as thicker, brighter edges. Thinner, darker edges are those routes that are more infrequent and less reliable for cargo transportation. These results reflect a 100% utilization of space-available routes if they exist. In reality, human operators may not be able to achieve such utilization rates, and thus the numbers indicate an upper-bound on performance. The upper-bounds are informative, and later in this section we compare results from lower utilization rates with these optimistic upper-bounds. Unless otherwise specified, the numbers for space-available logistic networks in this section reflect full utilization.

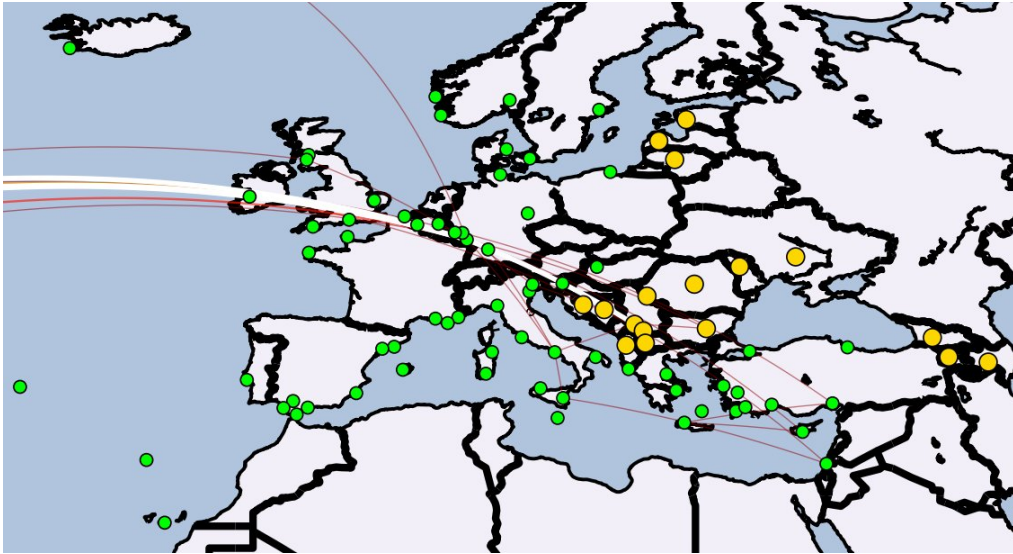


Figure 5. Scenario of transporting cargo to Montenegro using only space available on Air Force aircraft. Yellow dots represent possible cargo destinations and green dots represent possible transshipment locations. The edge colors and thicknesses represent the relative usage of those shipping routes. No edges are drawn when no route exists.

Table 6 lists the performance of various logistic networks for four hypothetical HA transportation instances. The four instances were derived from discussions with the

HA transportation programs and are based on likely availability of cargo and EUCOM HA requirements. The instances include: (1) shipping two pallets of school supplies from San Diego to Albania; (2) shipping two pallets of water filters from San Diego to Bosnia; (3) shipping an x-ray machine, approximately two pallets in size, from San Diego to Croatia; and (4) shipping two pallets of school supplies starting from Campbell Air Force Base (AFB) to Azerbaijan. The results assume a 2–4 week lag time for contractors to execute shipments. For a combined operation, if a space-available transportation leg that decreases total costs exists, it is combined with contracting to limit costs. Our results indicate that using only space-available transportation networks is insufficient for transporting COCOM HA cargo. In addition, the comparison of the contract network versus the combined operation network indicates that combined operation of space available plus contracting offers little benefit over contracting alone.

Table 6. Performance of four logistic networks against four hypothetical HA transportation instances. The results indicate that exclusively space-available networks (Navy and Air Force) are insufficient to transport HA material in a timely manner. In addition, a combined operation offers limited advantages over pure contracting. All pallets are standard Air Force pallets. Estimated transportation costs are rounded to the nearest one hundred dollars. The designation “N/A” stands for “not available” and means that transport using this logistic network is not possible because a feasible route is highly unlikely. The exclusively space-available networks (Navy and Air Force) can have slightly improved performance if any origin from CONUS can be used to initiate space-available transport. The expected wait times to EUCOM destinations, if any CONUS origin can be used, are depicted in Figures 6 and 7.

Origin	Destination	Material	Logistic Network	Wait (weeks)	Transport Cost (dollars)
San Diego	Albania	Two pallets of school supplies	Navy	N/A	N/A
			Air Force	N/A	N/A
			Contract	2-4	5,000
			Combined	2-4	5,000
San Diego	Bosnia	Two pallets of water filters	Navy	N/A	N/A
			Air Force	N/A	N/A
			Contract	2-4	5,600
			Combined	2-4	5,600
San Diego	Croatia	One x-ray machine, about two pallets in size	Navy	N/A	N/A
			Air Force	N/A	N/A
			Contract	2-4	5,000
			Combined	2-4	5,000
Campbell AFB	Azerbaijan	Two pallets of school supplies	Navy	N/A	N/A
			Air Force	66	0
			Contract	2-4	6,300
			Combined	2-4	6,200

The model yields expected wait times in weeks for Air Force space-available and Navy space-available transportation to the 17 destination countries. Figure 6 shows the expected wait times for Air Force space-available transportation and Figure 7 shows the expected wait times for Navy space-available transportation. These wait times contrast with the transportation instances in Table 6 because the cargo is assumed to originate in any CONUS location where a route is available; for example, through CONUS trucking. Of the 17 countries, only five exhibit wait times of less than a year for

Air Force space-available transportation: Romania, Montenegro, Bulgaria, Azerbaijan, and Georgia. The low wait times for Azerbaijan and Georgia are likely the result of operations in Afghanistan and would change as those operations decrease. In the case of Navy space-available transportation, the performance is similar. Only five countries, Bulgaria, Montenegro, Romania, Croatia, and Georgia exhibit wait times of less than a year. Combining these results, even under the optimistic assumption of full utilization of space-available routes, currently no military space-available transportation channels exist to 11 of the 17 EUCOM destinations of interest.

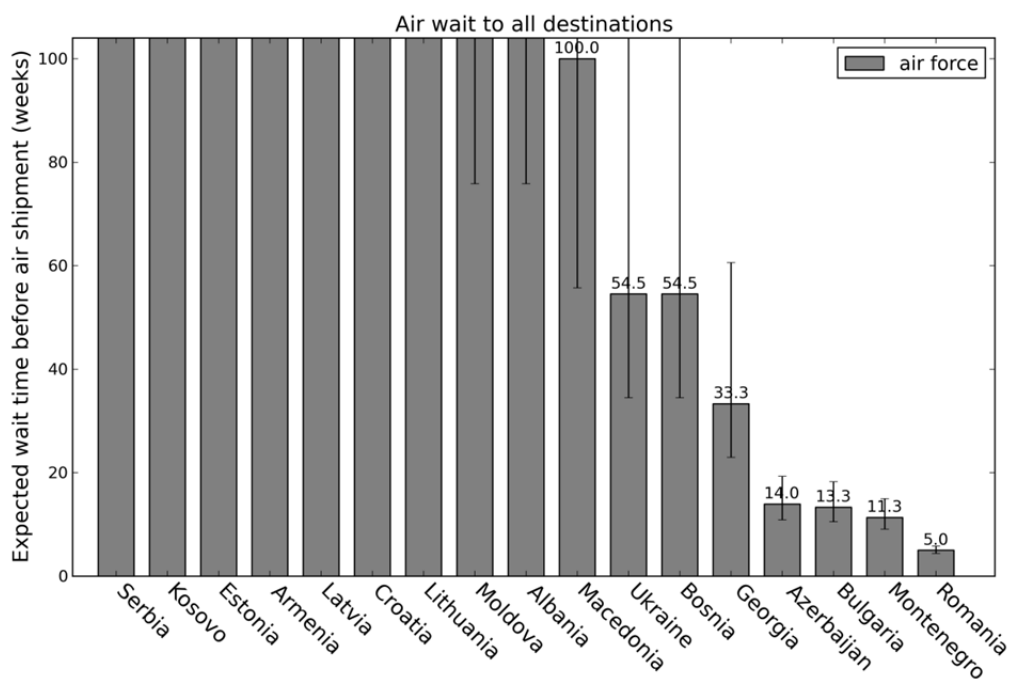


Figure 6. A bar graph of expected wait time for Air Force space-available cargo transportation, in weeks, by destination country. The vertical lines above the bars represent a 95% confidence interval. These wait times assume that cargo can originate in any CONUS origin, if a space-available route from that origin exists. The wait times also assume an optimistic 100% utilization of space-available routes. Even under such optimistic assumptions, only 5 of 17 EUCOM destinations exhibit wait times of less than one year.

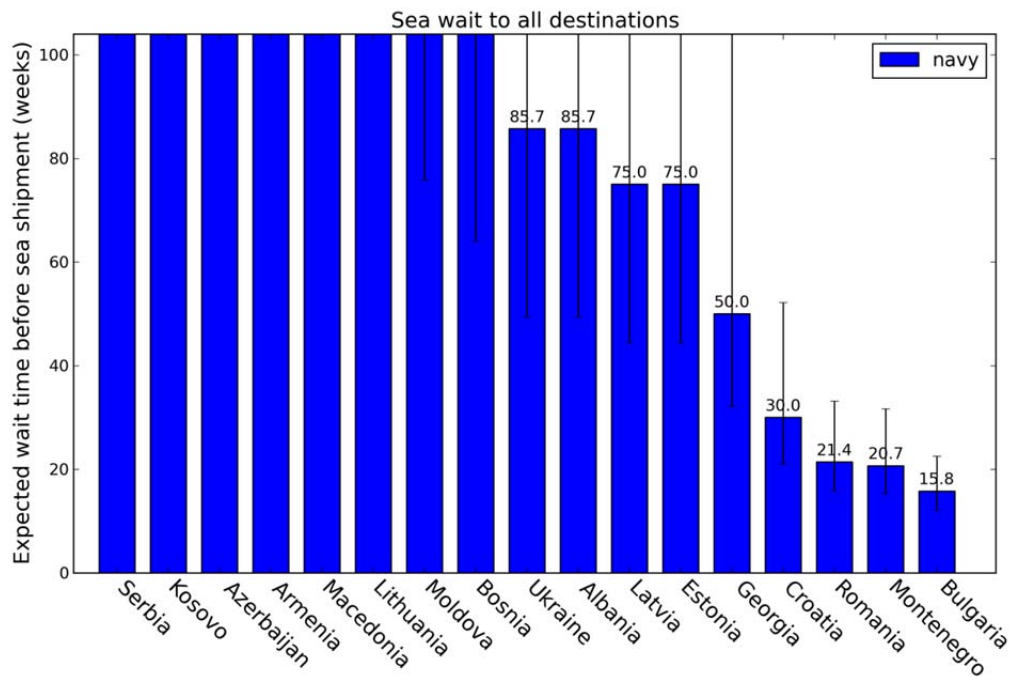


Figure 7. A bar graph of expected wait time for Navy space-available cargo transportation, in weeks, by destination country. This network includes Navy shipping and NALO flights. The vertical lines above the bars represent 95% confidence intervals. These wait times assume that cargo can originate in any CONUS origin, if a space-available route from that origin exists, as well as an optimistic 100% utilization of space-available routes. Even under such optimistic assumptions, only 5 of 17 EUCOM destinations exhibit wait times of less than one year.

Figure 8 depicts the three best and three worst destinations in terms of transportation capability of the combined logistic network. The three best destinations are Latvia, Lithuania, and Estonia. The three worst destinations are Georgia, Armenia, and Azerbaijan. The figure also depicts the performance of each of the four logistic networks, for each of these six country destinations. As exhibited by the preceding results, in general, the space-available networks have very little or no transportation capacity. The contract network and the combined network have roughly the same capacity for each destination because combined operations rely on contractors for the most part, substituting with space-available when possible. The best and worst destinations differ largely by the estimated contracting cost for shipping a pallet to the

destination. The combined network, because it can combine space-available and contracting, is always the logistic network with the highest transportation capacity; however, it offers relatively little benefit over contracting alone.

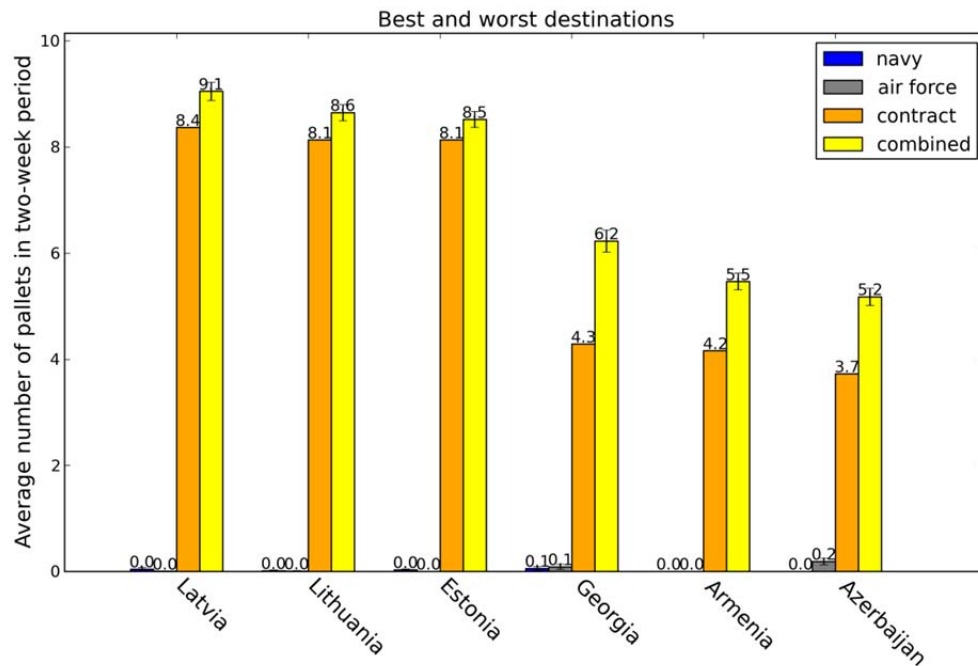


Figure 8. A bar graph of the average number of pallets delivered for four logistic scenarios to the three best-performing countries and the three worst-performing countries. The vertical axis represents the average number of pallets that can be transported in a two-week time period. Blue bars represent the Navy logistic network, orange bars the contract network, gray bars the Air Force network, and yellow bars the combined logistic network. The vertical lines above the bars represent 95% confidence intervals for the estimated performance of the network. Space-available networks generally offer little transportation capability to these countries. The contracting and combined networks have comparable performance, with combined operations outperforming slightly due to marginally smaller costs. For these results, a transportation budget of approximately \$10,000 per two-week time period is assumed, based on expenditures on the order of the FTP annual budget, allocated equally among geographic COCOMs and spread evenly throughout the year.

Figure 9 depicts the estimated cost of shipping a single pallet from San Diego to each of the 17 countries of interest in the EUCOM AOR. The figure contrasts the cost of shipping using contracting only as compared to a combined operation that uses space-available transportation when present. A combined operation allows for some decrease in cost, ranging from 15% to 30%, but does not offer significant shipping improvements. This is consistent with historic research on peacetime transportation using contractors (Lewis, 1995).

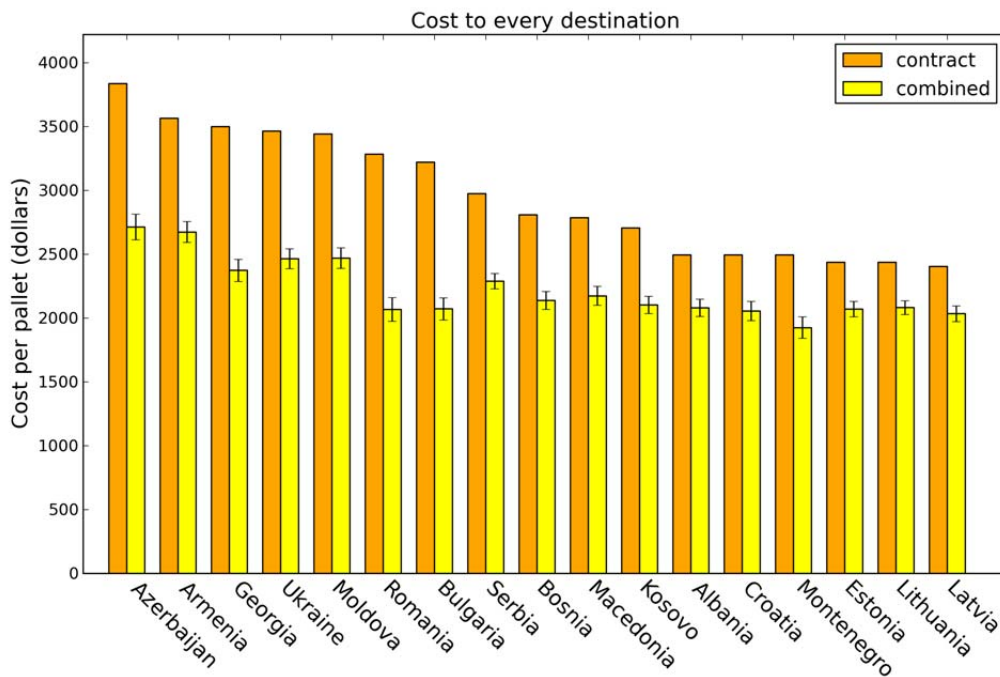


Figure 9. Estimated costs of shipping a single pallet to each EUCOM destination of interest. The orange bars represent costs using contract shipping only. The yellow bars represent costs from a combined operation, substituting space available for contract when possible. A combined operation offers approximately a 15% to 30% cost decrease over exclusively using contractors.

Finally, Figure 10 represents the total shipping capacity in pallets for a range of budget values. The vertical dashed line is at approximately \$10,000 per two weeks, which is approximately equal to \$260,000 per year—the value of splitting the FTP budget

equally among the geographic COCOMs. The right-most extent of the horizontal axis is at a budget of approximately \$55,000 per two weeks, or approximately \$1.5 million per year—the value of the entire annual FTP budget. The yellow line indicates the performance of a combined operation, while the orange line indicates a contract-only operation. For an equal budget allocation, the combined operation offers approximately two more pallets per two-week period than a contract-only operation. This is more significant at small budget values, but at a budget value of \$10,000 per two weeks, it is less than a 30% improvement.

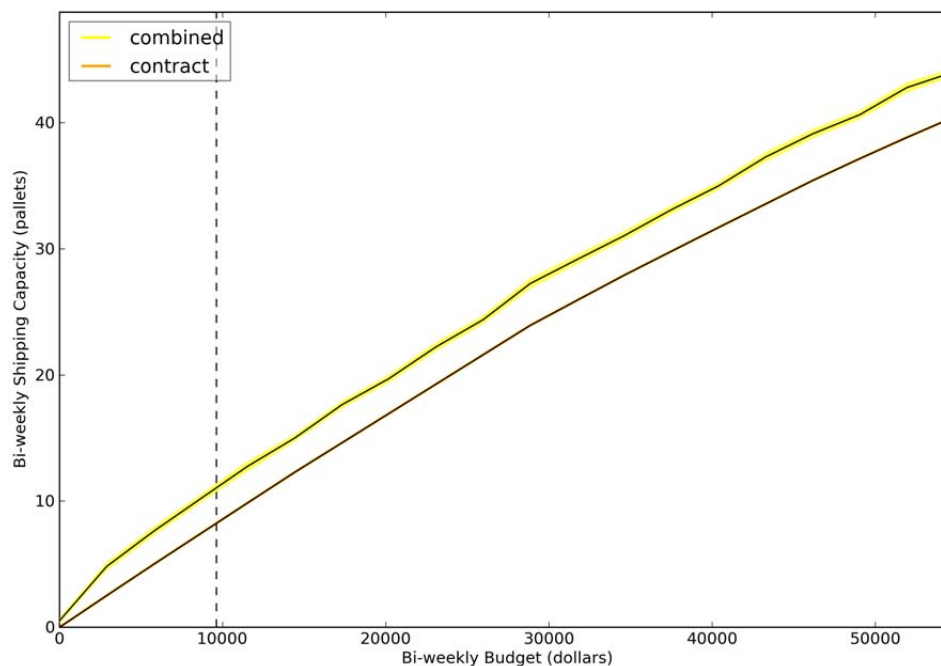


Figure 10. A comparison of contract-only operations and combined operations at a range of budget values. The vertical dashed line is at approximately \$10,000 per two weeks, or \$250,000 per year—the value of the FTP budget, split evenly across the geographic COCOMs. At this value, a combined operation offers less than a 30% increase in capacity when compared to contract-only operations.

B. DISCUSSION OF PROGRAM UTILIZATION OPTIONS

The current guidance from the United States Secretary of Defense to the COCOM HA staffs lists Denton and FTP as the methods for transporting HA material to a destination in need (United States Secretary of Defense, 2009). Operationally, these two programs are not focused to address the COCOM relationship-building mission. The programs are a public service by the DoD and are driven by NGO requests instead of COCOM priorities. Currently, there is no lead executor for HA cargo transportation that focuses on the COCOM relationship-building missions, requirements, and priorities. Table 7 provides a short summary of options for addressing this deficiency. For the remainder of this section, we discuss some of these options in greater detail.

Table 7. Summary of options for addressing COCOM HA cargo transportation strategic relationship-building mission. Currently, no agency focuses on COCOM priorities for HA cargo transportation.

Option	Discussion	Recommended?
1. Keep current system unchanged.	Provides no quality of service for COCOM HA missions. COCOMs may encourage and assist NGO applications for Denton and FTP. COCOMs may ask for assistance to task PH through NCCs.	No
2. Realign Denton/FTP to focus on COCOM missions.	Removes well-utilized and liked DoD programs. Negatively impacts relationships with NGOs and partners. Removes the beneficial impact of existing programs.	No
3. Give joint role to PH.	Builds on PH relationships with NGO partners and PH experience, expanding the program to non-Navy assets. Requires COCOM funding to execute COCOM mission. Requires adjustment and expansion of PH operations.	Yes
4. Create common execution of transportation between Denton, FTP, and PH.	Misapplies Denton and FTP to satisfy COCOM relationship-building mission. Has previously been attempted with little success. Provides no quality of service guarantee to COCOMs.	No
5. Create new program as lead executor.	Does not make use of existing expertise and capabilities in current HA cargo transportation programs.	No
6. Create multiple programs: for each service or for each COCOM.	Leads to confusion on the part of NGOs willing to assist. Significantly complicates congressional reporting requirements.	No

The three HA transportation programs differ in their ability to execute the EUCOM partnership-building mission. Both the Denton and FTP operate similarly as a public service provided by the DoD. Denton's purpose, legally and operationally, is to facilitate NGO-owned cargo transport for NGOs. The program is driven by NGO requests and, as such, using it to satisfy COCOM theater strategy would be a misapplication of the program. The program may be suitable for occasional requests by NGOs that happen to coincide with COCOM strategy, but no regular service for COCOMs can be expected. Because FTP has a similar purpose and operation as Denton, similar reasoning shows that it also is not ideal for executing COCOM HA missions.

One explored method of executing COCOM HA cargo transportation operations is using PHF as the acting NGO for Denton and FTP applications. Theoretically, such an approach would provide the PH process with multimodal transportation by giving it access to space available on Air Force planes through Denton and some funding from FTP. A SOUTHCOM Naval officer who worked with PH submitted applications on behalf of PHF to both Denton and FTP. These applications were unsuccessful for several reasons. First, the legal authority of Denton requires that the source of the transportation request be an NGO. Initially, because of the normal procedural validations of Denton and FTP applications, care had to be taken to ensure that PHF satisfied the legal definition of an NGO. After PHF was confirmed as a legitimate private sector organization, it could use the two programs. However, both Denton and FTP have the policy that no special treatment can be given to any one NGO over others. Thus, under this model, no quality-of-service guarantees can be made on PH's ability to use multimodal transportation. More importantly, this operational model is a misapplication of Denton and FTP because it attempts to use them to fulfill COCOM missions instead of their intended purpose—to provide a service to NGOs.

In contrast with Denton and FTP, PH is designed to be a mission-oriented program whose main purpose is to satisfy Navy strategic objectives by increasing perceptions of the United States Navy abroad. COCOM HA missions satisfy similar theaterwide strategic objectives.

The expertise and experience of PH could be used to achieve a similar mission for COCOMs as it does for the Navy: to improve perception of the United States military through the delivery of HA material. However, a number of operational changes would have to occur to facilitate such an expansion of the operations of PH.

C. METHODS FOR CREATING A JOINT ROLE FOR PROJECT HANDCLASP

Currently, PH is tasked and funded by the Navy to satisfy Navy mission objectives, and is limited to using Navy assets. To satisfy COCOM HA cargo transportation missions, PH would require a joint role that elevates its operations from satisfying solely Navy objectives to a standard service available to combatant commanders to satisfy COCOM HA cargo transport mission requirements. A general legal and financial outline of achieving this change in PH's operations consists of the following steps:

1. A COCOM incorporates the need to maintain and build relationships with countries in their AOR through Phase 0 programs—including the timely delivery of HA cargo—in their TSC strategy and approved operational plans.
2. A COCOM has the authority to organize the services to achieve its approved operational plans (Department of Defense, 2008). This allows a COCOM to organize the services to support PH in accessing the DoD's logistic capabilities.
3. A service, however, does not resource its forces to support COCOM objectives. Thus, a COCOM may also provide funding to achieve its approved, Phase 0, HA cargo transport objectives through its regular mission-funding routes. Such a funding step would enable PH to access both outside contractor transport and space-available, low-priority DoD transport, thus increasing its logistic capabilities beyond the use of only Navy assets.

4. Any DoD funding used for transportation of HA cargo falls under USC 10, Section 2561—the same authority used by FTP—and has the same requirements, such as annual reporting to Congress.

In order for the COCOMs to achieve their strategic relationship-building objectives, the process for transporting HA cargo should be standardized, with a predictable quality of service. Through the steps outlined above, a COCOM identifies this as a mission requirement, and funds it through its regular mission-funding pathways; for example, its OHDACA funds. It grants PH the ability to place cargo onto non-Navy and outside contractor assets for transportation of material that achieves the COCOM mission.

Operationally, a joint role for PH would allow for direct tasking of PH by COCOM HA staff. The current PH tasking by NCCs, combined with a lack of communication between NCCs and COCOMs, can lead to COCOM misperception of PH shipments as *push* shipments, even for deliveries initiated by NCC requests. Moreover, NCCs do not have dedicated staff for HA missions, as do COCOMs. Thus, direct tasking of PH by COCOM HA staff would increase transparency of shipments and improve the responsiveness of PH to COCOM theater objectives.

Direct tasking could be performed in the following manner. A COCOM could work with their local USAID representatives and the country teams to coordinate a priority list of material that would help with partnership-building. Such a priority list could be published and given regularly to PH to match these requests with donated materials in the PH inventory. Once material is identified, the COCOM HA staff, in conjunction with the recipient country team, could obtain the necessary duty-free and customs paperwork from the recipient country, and transportation could be executed by PH. Direct tasking by the COCOM HA staff would reinforce a pull transportation system for procuring needed material to the COCOM AOR vice pushing HA donations that recipient countries may or may not need. Because COCOMs would resource PH's joint role, the performance of PH could be measured not by pallets or total weight, but by the number of shipments that satisfy a COCOM's HA priorities.

Even with a joint role, PH would continue to execute its Navy mission. PH is well-positioned within the Navy's logistic organizations, and has good administrative support. Thus, it would be inadvisable to move PH to a different organization. Instead, the Navy could be designated as the executive agent for COCOM HA cargo transportation requirements and PH could provide transparency and work with DSCA to prepare the annual reports to Congress. Creating a joint role for PH could pose relatively little administrative and operational effort and only a few policy changes, but would require high-level tasking from COCOMs, Navy commanders, and DoD HA officials.

Throughout the process, care must be taken on several legal requirements. First, at no point should donations be solicited from outside agencies. Second, cargo transported through HA transportation programs should satisfy a legitimate humanitarian need. Third, congressional reporting requirements for use of HA funding and transportation should be observed.

VI. CONCLUSIONS

A. UNITED STATES EUROPEAN COMMAND STRATEGIC IMPORTANCE

EUCOM would like to partner with NGOs and use deliveries of NGO-owned material to build and maintain strategic relationships within their AOR. Delivery of HA material and direct involvement by DoD personnel improves perception of the DoD and its mission. The effects of these donations remain long after the material is distributed, helping to build long-lasting partnerships with foreign nations. By providing the mechanism for HA cargo delivery to countries in need, EUCOM is able to make steps toward regional security and stability, which consequently impacts the support our partners provide toward our global initiatives (United States European Command, n. d.).

B. MODEL CONCLUSIONS

The results of our analytical model indicate that space-available transportation is insufficient to address EUCOM HA shipping requirements. In addition, a cost comparison between contract-only operations and combined operations shows limited improvement for a combined operation. This, combined with the relatively easy execution of contract-only operations, suggests that allowing for contract transportation of EUCOM HA material may be a reasonable method of providing quality service for the COCOM relationship-building mission at a relatively low cost.

While the model presented here is derived using current and thorough input data, as well as modern modeling techniques, in any model there is no way of accounting for the multitude and complexity of human factors that make the real-world logistics operations work. Although critical to daily operations, these are elements that are impossible to model mathematically. Nevertheless, model results can provide insights into the capabilities of different logistics operations and the relative merits of varying policy decisions.

C. FUTURE WORK

The method described in this paper provides a way for combatant commanders to evaluate the performance of DoD HA programs, given an operational budget, in order to achieve their strategic goals. We use a network model in which the stochasticity comes from an empirical distribution on available capacities derived from historical transportation data. This method is effective for the purpose of this initial study. However, there are several other ways these data could be analyzed to incorporate a few aspects of this problem that are not included in the current model.

Devising a time-phased model similar to Ahuja, Magnanti, and Orlin (1993) to evaluate the introduction of potential storage locations could result in transportation systems with increased reliability. A time-phased model could provide insights regarding optimal locations to build or maintain a storage facility, or how to effectively utilize existing storage facilities for forward-staging materials within the AOR. Further developments could provide recommendations on the types of materials to forward-stage, as well as the time period and location in which to store them. This potential avenue of study could also model stochastic demands, in the sense of probabilities that certain countries need certain materials at certain times.

In the case of EUCOM, destination country needs are fairly predictable since they are not primarily in response to a natural disaster. The problem of disaster relief requires a different model from our less time-sensitive approach. In the case of EUCOM, an effective method of delivering development aid is necessary, whereas in other COCOMs, such as PACOM, an effective disaster relief method may be much more relevant.

A non-quantitative area of future study in which all COCOMs could benefit is the potential for PH to be given a joint role in the military. Since we recommend that PH be in the executor of long-term development COCOM HA cargo transportation missions, the program would most likely need to become a joint program. This way, instead of falling exclusively under Navy rules and jurisdiction, they would operate under joint guidelines. This would also allow PH access to all services' assets to achieve COCOM HA objectives. However, this is a complicated endeavor that would potentially require several legal and procedural changes.

The results from our analytical model assume an optimistic 100% utilization of space-available when present. In reality, human operators are likely unable to achieve such a degree of utilization without significant automation improvements. One effort to create such automation improvements is the United States Fleet Forces Command's Lifts of Opportunity/Opportune Lift Program administered by the Navy Supply Logistics Operation Center. The goal of the program is to consider all scheduled conveyances and search for opportune lift. One aspect of the program is an automated Transportation Exploitation Tool (TET) available on the Secret Internet Protocol Router Network through a collaborative effort with the United States Department of Energy. The TET prototype provides a search capability similar to an internet search engine for opportune lift. This type of technology, if utilized by the DoD HA programs, has the potential to change their procedures and operations. An analysis of the benefit to HA operations offered by TET may be a relevant future research question.

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LIST OF REFERENCES

- Ahuja, R.K., Magnanti, T.L., & Orlin, J.B. (1993). *Network flows*. Englewood Cliffs, NJ: PrenticeHall.
- Counterpart International. (2012). *Small medium transportation program*. Counterpart International. Retrieved from <http://www.counterpart.org/working-with-us/contracting-vehicles/smtip>
- Defense Security Cooperation Agency. (2003). *Security assistance management manual (SAMM) DoD 5105.38M*. Washington, D.C.: Defense Security Cooperation Agency.
- Defense Security Cooperation Agency. (2010). *Fiscal year 2009 report on humanitarian assistance*. Washington, D.C.: Defense Security Cooperation Agency.
- Department of Defense. (2008, July 18). *Joint logistics*. Joint Publication 4-0. Washington, D.C.: Department of Defense.
- Department of Defense. (2011). *The national military strategy of the United States of America: 2011 redefining America's military leadership*. Washington, D.C.: Chairman of the Joint Chiefs of Staff.
- Evans, J.R. (1976). Maximum flow in a probabilistic graph-the discrete case. *Networks*, 6, 161–183.
- Funded Transportation Program. (2011). *Denton/funded transportation program guideline* [PDF document]. Retrieved from <https://hatransportation.ohasis.org/FundedTransportationProgram/FundedTransportationProgramGuidelines.pdf>. Washington, D.C.: Defense Security Cooperation Agency.
- Humanitarian Assistance. (2011). In *United States Code for Armed Forces: Title 10* (Subtitle A, Part IV, Chapter 152, Section 2561). Retrieved from http://www.law.cornell.edu/uscode/usc_sec_10_00002561----000-.html
- Jayasuriya, S., & McCawley, P. (2010). *The Asian tsunami: Aid and reconstruction after a disaster*. Northampton, MA: Edward Elgar.
- Joint Relief International, Inc. (2011). *Denton: Fiscal year 2010 & 2011*. Charleston, SC: United States Transportation Command.
- Lewis, T.A. (1995). *A comparison of AMC cargo channel flights and alternative commercial air freight carriers* (Master's Thesis). Monterey, CA: Naval Postgraduate School.

- Lin, Y., Batta, R., & Rogerson, P. (2009). Application of humanitarian relief logistics model to an earthquake disaster. *Word Journal of the International Linguistic Association*, 1–14.
- Norman, K.W. (2011, March 2). Denton amendment allows Altus AFB to support humanitarian operations. Air Education and Training Command. Retrieved from <http://www.aetc.af.mil/news/story.asp?id=123244904>
- Office of the Chief of Naval Operations. (2006). *Project Handclasp*. Instruction 5726.3D. Washington, D.C.: Department of Defense.
- Oloruntoba, R., & Gray, R. (2006). Humanitarian aid: An agile supply chain?. *Supply Chain Management: An International Journal*, 11(2), 115–120.
- Salmeron, J., & Apte, A. (2010). Stochastic optimization for natural disaster asset prepositioning. *Production and Operations Management*, 19(5), 561–574.
- Salmeron, J., Kline, J., & Densham, G. S. (2011). Optimizing schedules for maritime humanitarian cooperative engagements from a United States Navy sea base. *Interfaces*, 41(3), 238–253.
- Stavridis, J.G. (2010). *Partnership for the Americas: Western Hemisphere strategy and U.S. Southern Command*. Washington, D.C.: National Defense University Press.
- Thomas, A., & Kopczak, L. (2005). From logistics to supply chain management: The path forward in the humanitarian sector. *Fritz Institute*, 15, 1–15.
- Transportation of Humanitarian Relief Supplies to Foreign Countries. (2011). In *United States Code for Armed Forces: Title 10* (Subtitle A, Part I, Chapter 20, Section 402). Retrieved from http://www.law.cornell.edu/uscode/usc_sec_10_00000402----000-.html
- United States European Command. (n.d.). *A strategy of active security* [PowerPoint slides].
- United States Navy Project Handclasp. (2009). U.S. Navy's Project Handclasp: Consolidated report for CY09 [Data file].
- United States Secretary of Defense. (2009). *Policy guidance for DoD overseas humanitarian assistance program (HAP)*. Washington, D.C.: United States Secretary of Defense.
- Van Wassenhove, L., Martinez, & A. P. (2010). Using OR to adapt supply chain management best practices to humanitarian logistics. *International Transactions in Operational Research*, 19, 1–16.

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